NASA's Multi-Mission Payload, Mission Specific Evolved Expendable Launch Vehicle Secondary Payload Adapter (ESPA) System Interface Specifications (SIS) For Heliophysics Missions of Opportunity

Date:

1.0 Introduction

1.1 Purpose

This document defines requirements and guidelines for a Rideshare Payload for proposals submitted to the Heliophysics Science and Technology Demonstration Missions of Opportunity that utilize the Evolved Expendable Launch Vehicle Secondary Payload Adapter (ESPA) accompanying the Interstellar Mapping and Acceleration Probe (IMAP) mission.

This document was developed by NASA Science Mission Directorate (SMD) Heliophysics Division (HPD).

1.2 Scope

This document provides ground rules and assumptions for Rideshare Payloads intended to launch on the IMAP ESPA, as well as specific interface requirements and generic environment definitions that will not be formalized until the IMAP Launch Vehicle Provider has been selected.

This document also includes Rideshare Mission Assurance (RMA)/Do No Harm (DNH) requirements that focus on ensuring safety of flight for the primary mission and other rideshare payloads.

Additional RPL requirements will be accommodated using the mission-specific or mission unique hardware processes, or services as specified by the Launch Vehicle to Payload Interface Control Document.

NOTE: For this document the ESPA and the ESPA aggregator contractor are considered part of the Launch Vehicle (LV)/Launch Vehicle Contractor (LVC) and/or Government.

Need to add a discussion on standard rideshare payload acronyms and definitions: RPL, APL, MMP, Secondary PL. ETC.

1.3 Definitions

- CCAMs – Contamination Control Avoidance Maneuvers
- DNH – Do No Harm
- ESPA – Evolved Expendable Launch Vehicle Secondary Payload Adapter
- HPD – Heliophysics Division
- IMAP – Interstellar Mapping and Acceleration Probe
- IPS – Integrated Payload Stack – Fully integrated ESPA with mated RPL
- LSP – Launch Service Provider
- LV – Launch Vehicle
- LVC – Launch Vehicle Contactor
- RPL – Rideshare payloads
- RMA – Rideshare Mission Assurance
- SMD – Science Mission Directorate
- TBD – To Be Determined

- TBR – To Be Resolved
- TBS – To Be Supplied

2.0 Documents

2.1 Applicable Documents

- AFSPCMAN 91-710 Range Safety User Requirements Manual Volume 3 – Launch Vehicle, Payloads, and Ground Support Systems Requirements
- NPR 8715.6 NASA Procedural Requirements for Limiting Orbital Debris
- NASA-STD-6016 Standard Materials and Processes Requirements for Spacecraft

2.2 Reference Documents

- EELV RUG Evolved Expendable Launch Vehicle Rideshare User's Guide (SMC/LE)
- TOR-2016-02946 Rideshare Mission Assurance and the Do No Harm Process – Aerospace Report
- GSFC-STD-7000 General Environmental Verification Standard (GEVS) for GSFC Flight Program and projects
- MMPDS Metallic Materials Properties Development and Standardization
- MIL-HDBK-5 Military Handbook 5, Metallic Materials and Elements for Aerospace Vehicle Structures
- *EELV SIS* *Evolved Expendable Launch Vehicle Standard Interface Specification*
- *LSP-REQ-317.01B* *Launch Services Program Program Level Dispenser and CubeSat Requirements Document*
- MIL-STD-1540C Military Standard Test Requirements for Launch, Upper-Stage, and Space Vehicles

3.0 Ground Rules and Assumption

3.1 The Government and/or LVC will provide the following

3.1.1 In a case where any of the rideshare payloads are not able to meet the required mass properties, milestone schedule or determined by the NASA be unfit to launch the NASA has the right to replace the RPL with an equivalent mass simulator or with a backup RPL if available. Note mass simulators will be hard mounted to the ESPA Port (non-separating).

3.1.2 Mass Simulators will be provided by the Gov. (or LVC/ESPA Integrator)

3.1.3 LVC will coordinate RPL deployment time and sequencing with all invested stakeholders.

3.1.4 LVC will demonstrate, post RPL separation, no contact between RPLs, upper stage, primary payload and will not impede upper stage Contamination Control

Avoidance Maneuvers (CCAMs) until RPL activates propulsion systems.

3.1.5 LVC will provide Orbital Parameter Message for when RPL deployment signal is sent from the LV.

3.1.6 LVC will provide the RPL separation signal (primary and redundant) to each RPL or to an ESPA sequencer.

3.1.7 LVC will provide confirmation of RPL separation over interleaved telemetry.

3.1.8 LVC will provide confirmation of separation for CubeSat deployments of dispenser door open.

3.1.9 LVC/NASA will procure and coordinate with RPL to determine an appropriate 24" separation system for the mission.

3.1.10 LVC may provide accommodations for RPL GN2 purge systems from RPL arrival at integration facility thru launch.

3.1.11 Facility space will be provided at the ESPA aggregator. It can be used for RPL's to receive, unpack, functional checks, battery charging, facility power, standard temperature/humidity.

3.1.12 Clean room environment will be provided for integrated Contamination Control Environments to meet contamination.

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3.2 RPLs will not have the authority to make a GO, No-GO call on day of launch.

3.3 RPLs will not have the authority to change launch readiness date of IMAP.

3.4 At a minimum, the RPL will be required to provide the following data products to meet the IMAP Mission Integration Cycle. See appendix A for a general mission integration cycle for rideshare.

- Computer-Aided Design (CAD) Model
- Finite Element Model (FEM)
- Thermal Math Model (TMM)
- Venting Model
- Official Mass Properties Data
- Safety Data Package
- Test Procedures
- Separation Systems Characteristics
- Slosh Model (if applicable)

3.5 RPL's will need to meet primary mission integration Cycle (e.g. PGAA-1, 2, 3, FDLC and Verification Load Cycle (VLC)) See Appendix A for a general ESPA Rideshare integration schedule.

3.6 RPL will have no physical access post fairing encapsulation this includes launch delays/scrubs.

3.7 No telemetry support will be provided for RPL deployments.

4.0 Rideshare Mission Assurance and Do-No-Harm

As Rideshare missions become more feasible and accepted in today's space and science industry, there is a growing need to mitigate risks from the rideshare payloads to the primary mission and all

payloads on the mission. Department of Defense (DoD) Space Test Program (STP) has implemented a hybrid system of risk mitigation called Rideshare Mission Assurance (RMA). The objective of the RMA process is to provide all mission partners with a degree of certainty that all payloads included on a mission will do no harm (DNH) to each other, or to any operational aspect of the launch. The DoD Space Test Program developed a Rideshare Mission Assurance Do-No-Harm (TOR-2016-02946) guideline document. This document is only releasable to Government and Government contractors, and will not be in the program library.

The RMA process mitigates risks by assessing each payload flying on a mission against a tailored set of criteria, known as "Do No Harm" criteria. The primary concern of the RMA process is to ensure that the payloads are robust enough to survive the environments experienced during launch and/or will not inadvertently function. Other areas also assessed, includes any co-use of facilities during the launch campaign and the critical function inhibit scheme utilized by the payload. The focus of this process is to ensure safety of flight for all mission partners and is not to ensure mission success for individual rideshare payloads. It is the responsibility of the Payloads to ensure their own mission success.

This document incorporates key elements of the RMA process for this early procurement and concept development phase. Once the LVC is on contract, this process will be formalized and a detailed mission specific set of Do-No-Harm criterial will be developed and validated as part of the overall mission integration cycle.

5 Requirements:

5.1 Mission Trajectory:

At this stage in the IMAP mission development, the trajectory and RPL orbit insertion are still to be determined, therefore RPL should consider a range of orbit insertions from:

High Energy Earth Orbit (C3= -0.8 to -0.1 km2/s2)
Escape (C3 = 0 km2/s2) or higher

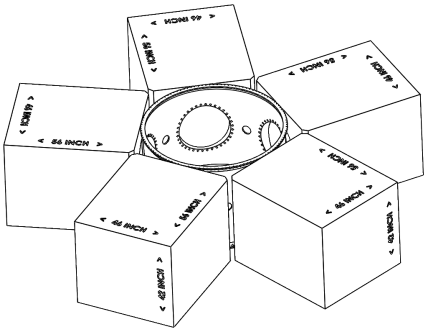
The declination and right ascension directions will be determined by the primary spacecraft, which is targeting a transfer orbit to a Sun-Earth L1 Lissajous Orbit. The RPL orbit insertion shall be designed not to make physical contact with the primary spacecraft or LV performing end of mission operations; its target, including C3, will be dependent on excess capability of the launch vehicle after inserting the primary spacecraft.

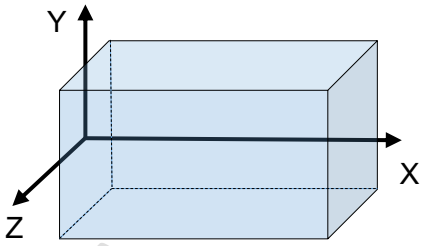
5.2 Mechanical

4.1.1. Reference Coordinates and Origin

4.2.1.1 RPL will use the coordinate system specified in Figure 4.1.

Figure 4.1 ESPA and RPL Coordinate System





4.2.2 ESPA Class Payloads Interface Requirements

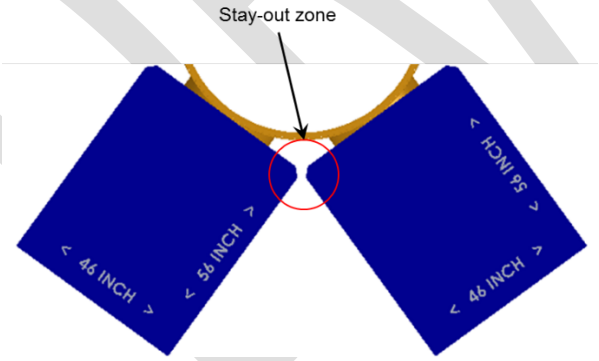
4.2.1.2 RPLs shall not exceed the mass and volume requirements as specified in Table 4.1.

Table 4.1 ESPA RPL Mass, Volume, Interface Requirements

ESPA	Max RPL Mass	Allowable RPL Volume	RPL Interface
ESPA 5 Port (PN: 5-24-42)	320 kg(1)	42”x46”x38” (2, 3, 4) Y, X, Z	24” circular

(1) ESPA is being requalified for increased RPL mass
(2) This assumes a 4 meter fairing
(3) 2” x 2” dynamic clearance stay-out zone on the inboard vertical corners of the allowable volume are shown in Figure 4.2.
(4) Additional static clearance stay-out zones may need to be considered based on LV and LV configuration. See LV provider’s users guides for detail stay-out limitations.

Figure 4.2, RPL Volume Stay-Out Zone



4.2.1.3 RPLs shall maintain a center of mass between 17” and 20” along the RPL X-axis from the port interface plane and be within 5% of the allowable volume height (Y axis) and width (Z axis) along the RPL X- axis centerline in previous requirement. (TBR)

4.2.3 ESPA Class Separation Systems: (TBD)

4.2.4 Static Loads (TBS, this section is being revised by LSP Loads and Environments group)

4.2.5 RPL Stiffness

4.2.5.1 RPL shall have first fixed-free fundamental frequencies above 75 Hz constrained at the Sep System interface plane.

4.3 Electrical Requirements

4.3.1 Electrical Power

4.3.1.1 RPLs shall be powered off from the time of integration thru deployment.

4.3.2 Connectors: (TBS)

4.3.2.1

4.3.3 Battery:

Battery charging can be provided thru an ESPA T-0 connector. Battery charging will not be provided during integrated operation or hazardous operations. LVC will provide RPL telemetry for battery monitoring data up until Launch/T-0. **(TBR)**

4.3.3.1 RPLs shall utilize Underwriter Laboratory (or-equivalent) approved batteries with no modifications and be compliant with Range Safety requirements (AFSPCMAN-91-710).

4.3.3.2 RPL shall meet battery charge monitoring requirements per AFPSCMAN 91-710. RPL monitoring of the charge activity will be required to avoid generation of RF emissions that may affect nearby hardware.

4.4 Environments:

This section contains general requirements for early development/design because mission-specific environments have not been defined. Mission specific environments will be defined once the launch vehicle contractor and primary observatory has been selected and the IMAP mission integration cycle has begun. These Mission specific environments will be flowed down to the RPLs from the Launch Vehicle to IMAP Interface Control Document (ICD). The environments defined in the LV to IMAP ICD will take precedence over the requirement defined in this section.

4.4.1 Thermal (TBR)

4.4.1.1 RPL shall not specify any specific temperature and humidity requirement.

4.4.2 Random Vibration (TBS, this section is being revised by LSP Loads and Environments group)

4.4.2.1

4.4.3 Acoustics (TBS, LSP Loads and Environments group will Provide)

4.4.3.1

4.4.4 Shock (TBS, LSP Loads and Environments group will Provide)

4.4.4.1

4.4.5 Pressure

4.4.5.1 RPLs shall demonstrate compliance with pressure decay rate during LV ascent.

4.4.6 Contamination

The IMAP spacecraft is highly sensitive (ISO Level 7 (Class 10,000) contamination control) *to both molecular and particulate contamination, as a result, strict cleanliness requirements must be placed on secondary payloads and will be documented in the LV to IMAP ICD. Surfaces within the fairing volume shall meet the IMAP requirements unless proven through contamination transport analysis to not pose a contamination threat to the IMAP observatory.*

4.4.6.1 RPLs shall be cleaned, certified and maintained to level 500A per IEST-STD-CC1246.

4.4.6.2 RPLs shall undergo thermal vacuum bakeout per ASTM E2900.

4.4.6.3 RPLs material selection shall be in accordance with NASA-STD-6016 Standard Materials and Processes Requirements for Spacecraft.

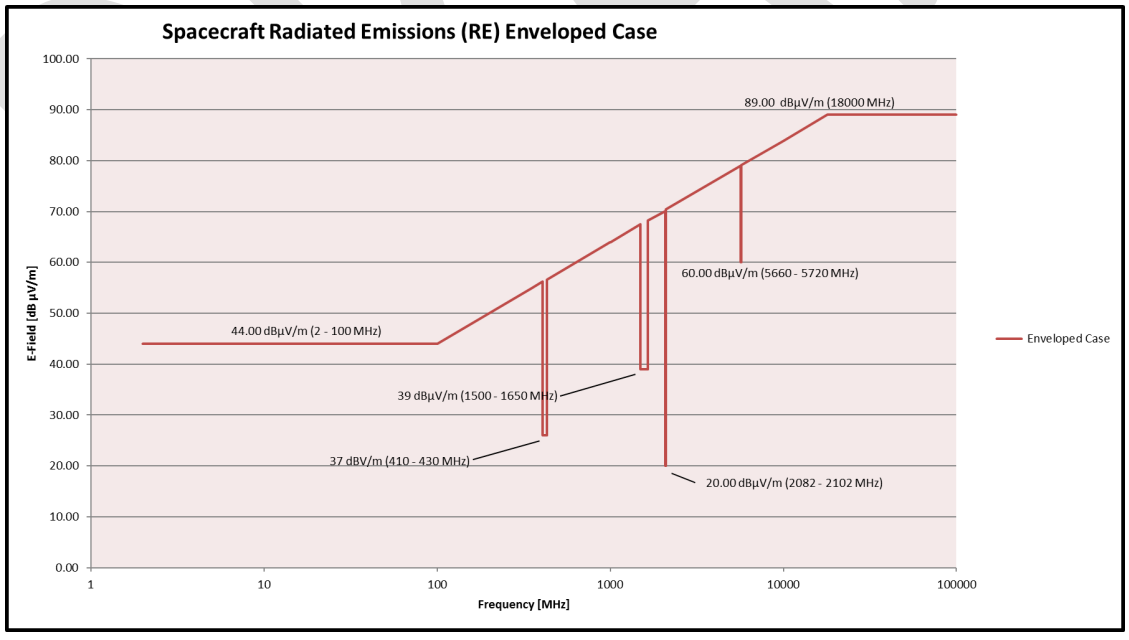
4.4.6.4

4.4.7 EMI/EMC

4.4.7.1 RPLs shall not conduct free radiation during launch processing. “Plugs out” testing may be conducted with antenna hats.

4.4.7.2 RPLs shall ensure Underwriter Laboratory (UL) or equivalent certification on all electrical ground support equipment (EGSE).

4.4.7.3 The RPLs radiated emissions at the payload interface plane shall not exceed the levels shown in Figure TBD.



4.4.7.4 The RPLs shall be compatible with the launch vehicle and Range radiated emissions as shown below:

20 V/m	2 MHz to 18 GHz
TBD V/m	TBD ±TBD MHz (launch site and launch vehicle telemetry transmitters)

4.4.7.5 The RPLs shall meet the following EMI margin requirements:

4.4.7.5.1 Electroexplosive Devices (EED) - The RPLs shall demonstrate a 20 dB Electro- Magnetic Interference Safety Margin (EMISM) to the RF environment (vs. dc no-fire threshold) for all EED firing circuits.

4.4.7.5.2 Safety Critical Circuits - The RPLs shall demonstrate a 6 dB EMISM to the RF environment for all safety critical circuits and circuits that could propagate a failure to the launch vehicle.

4.4.7.4 RPLs shall be magnetically clean from encapsulation through separation on orbit, with magnetic fields less than or equal to 1 Gauss at 1 meter from the RPL and all ground support equipment (GSE).

4.4.8 Radiation (TBD)

4.4.8.1 TBD

4.5 Ground Operations

4.5.1 RPLs shall provide GSE lifting fixtures to support mate operations onto the ESPA.

4.5.2 RPLs shall provide their own GSE.

4.5.3 (TBD)

4.6 U-Class Containerized (CubeSat) RPLs Requirements

4.6.1 RPLs proposing U-Class payloads shall provide their own flight qualified dispenser system that will be hard mounted to the ESPA Port and meet the following requirements;

4.6.1.1 U-Class Containerized (CubeSats) RPLs shall provide deployment systems that interface with and meets the ESPA interface requirements as stated in 4.2.1 and 4.2.2 (TBR).

4.6.1.2 U-Class Containerized (CubeSats) RPLs deployment systems shall meet the requirement as stated in (TBR)

4.6.1.3 U-Class Containerized (CubeSats) RPLs shall meet the requirement as stated in (TBR) or exception base list.

5 Safety

5.1 Fault Tolerance

5.1.1 All inhibits to hazardous operations (such as deployments of deployables, RF transmission and propulsion activation) shall be dual fault tolerant. (TBR)

5.2 Hazard System activation

5.2.1 RPLs shall have the ability to activate hazardous systems based on time limit identified in the LV to IMAP mission ICD. These hazardous systems may consist of, but are not limited to:

- Deployments of solar arrays, booms, and antennas etc.
- RF transmission

- Propulsion system
- Any other systems

5.2 Propulsion and Pressure vessels

5.2.1 RPLs with pressure vessels shall comply with Range Safety (AFSPCMAN-91-710) standards and be DOT certified.

5.3 **Hazardous Materials**

5.3.1 RPL hazardous material shall conform to AFSPCMAN 91-710, Range Safety User Requirements Manual Volume 3 – Launch Vehicles, Payloads, and Ground Support Systems Requirements and be DOT certified.

5.4 Orbital Debris

5.4.1 RPLs mission design and hardware shall be in accordance with NPR 8715.6 NASA Procedural Requirements for Limiting Orbital Debris.

Appendix A - General Guideline of Primary Mission Integration Cycle

Timeline (TBR)			
Rideshare Activity	**General Timeline**	**Source**	**Comment**
Release Final LSTO	L-44	LSP	ESPA Req. Included
Early CLA for Spacecraft CDR (pre selection CLA)	L-40	LV Prog	Include ESPA with mass simulators
LSTO Proposals Due	L-42	LV Prog	
Launch Vehicle Selection	L-36	HQ	
Perform Preliminary Loads Cycle (CLA #1)	L-33	Prog	Assess envelope potential range of ESPA payloads
Initial ESPA FEM	L-28	RUG	Initial ESPA FEM
Mass Simulators delivered to ESPA I&T facility	L-24	Prog	Support ESPA Test verified FEM with mass simulators
Perform Final Loads Cycle (CLA #2)	L-24	LV Proc	This analysis must envelope all potential configurations for the secondary payloads to establish bounding CLA levels for Primary prior to environmental test
Approval of RS P/L Inclusion	L-18	RUG	Final date to add RPLs
Finalize the mass of the Rideshare Payloads	L-14	Prog	
RPL provide test verified FEM	L-12	Prog	Last update to ESPA for FEM
Verification CLA (VLC) (CLA #3)	L-12	LV Proc	
Updated Trajectory Study (3 of 4)	L-12	LV Proc	
Rideshare P/Ls delivered for P/L-to-ESPA I&T	L-4	RUG	
ESPA w/ P/Ls delivered for ESPA-to-L/V I&T	L-2	RUG	
Final Trajectory Study (4 of 4)	L-1	LV Proc	
Launch	ILC		